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Design a Nocturnal Solar Light Bulb in 60 Minutes

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Learning Objectives

- Learn how to design enclosures for printed circuit boards inside Fusion 360.
- Discover the principles of basic electronics, solar panel, and battery calculations.
- Discover the best practices for ECAD-MCAD integration.

Description

Solar energy is clean and limitless, and the operational costs are close to nothing once you've installed a solar panel as no fuel is needed to create a considerable amount of energy. And a single kerosene wick burns an estimated 80 liters of fuel, producing more than 250 kilograms of carbon dioxide per year. To help people living in remote places with limited access to electricity, we made a low-cost solar light bulb as a replacement to a harmful kerosene lamp. We will share the technical workflow while creating the solar lamp inside the Fusion 360 Electronics and Modeling workspace, demonstrating an effective ECAD—MCAD collaboration.

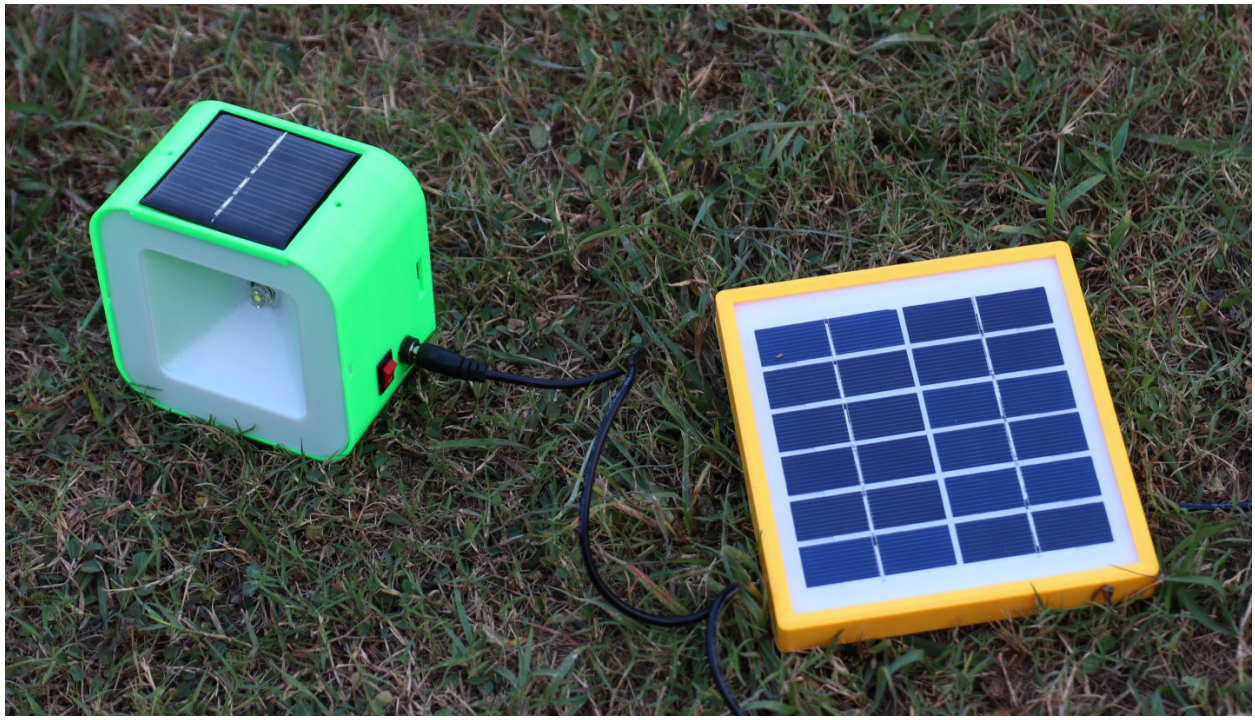
Speaker(s)

- Varun Heta | Autodesk Community Manager
- Debasish Dutta | Founder - Open Green Energy

DIY Solar Lamp

Introduction:

Solar energy is clean and limitless, and the operational costs are close to nothing once you've installed a solar panel as no fuel is needed to create a considerable amount of energy. To help people living in remote places with limited access to electricity, we made a low-cost solar light bulb as a replacement to a harmful kerosene lamp.



We will share the workflow while creating the solar lamp inside the Fusion 360 Electronics and Modeling workspace.

Benefits:

- Use of the solar lamp will decrease the amount of local air pollution and saves energy.
- It also came out as an alternative business model with the potential to strengthen the overall rural economy by generating technology-based livelihood opportunities.
- It can provide access to solar lamps at an affordable price to a wide range of audience living in the remote villages that are deprived of clean energy access.

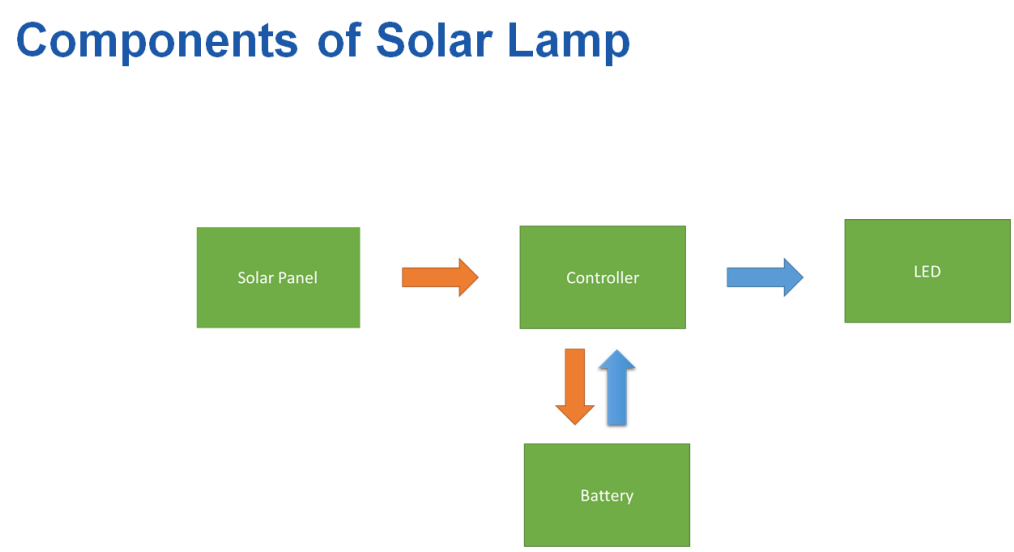
Supplies

- Solar Panel -2V
- IC QX5252F
- 33uH Inductor
- 8mm Straw Hat LED
- Switch
- DC Jack
- AA NiMh Battery
- Battery Spring Plates
- 24 AWG wires
- Heatshrink Tubing
- JST male-female connectors
- PCB / Perforated Board
- 1W Solar Panel (3 - 5V)

Tools Required:

- Soldering Iron
- Wire Cutter / Stripper

Step-1: Components of Solar Lamp

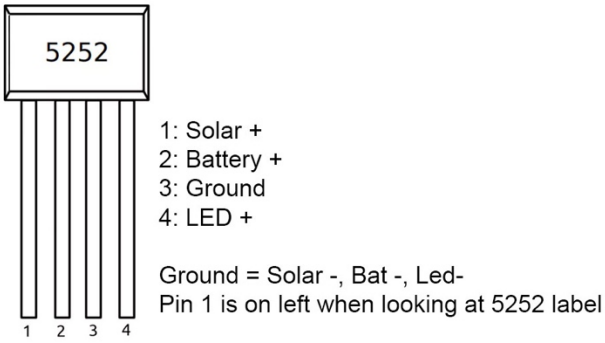


The solar lamp is a standalone SPV system and contains four components of Standalone SPV system:

- Solar Panel: Convert Solar Energy to Electrical Energy

- Controller : Charge the Battery (Charger) and drive the Load (Driver)
- Battery : Store the Electrical Energy
- Load (LED) : Provide the desired light output

Step-2: Controller Selection



The controller has two tasks

Charging the Battery

Isolate the Solar Panel and Battery when the battery is fully charged and Isolate the load from Battery when the battery voltage is low.

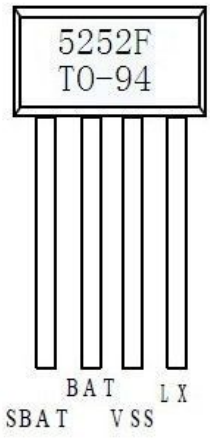
Driving the LED

Capable to drive the selected LED (ability to handle the required voltage and current) i.e Boost the battery voltage (1.2V) to LED operating voltage (3.2V) or higher. Here we will use a cheap QX5252F IC as a controller.

The main features are:

- Suitable for a single AA NiMh/NiCd battery
- Operating Voltage: 0.9V-1.5V
- Output current: 3mA-300mA (Our requirement is 93.7mA)
- Integrated Schottky Diode
- High Efficiency up to 84%
- Low quiescent current: 17uA (When the circuit is not working / standby)
- Only an external inductor is required for making the Circuit

Step-3: How the Circuit Works?



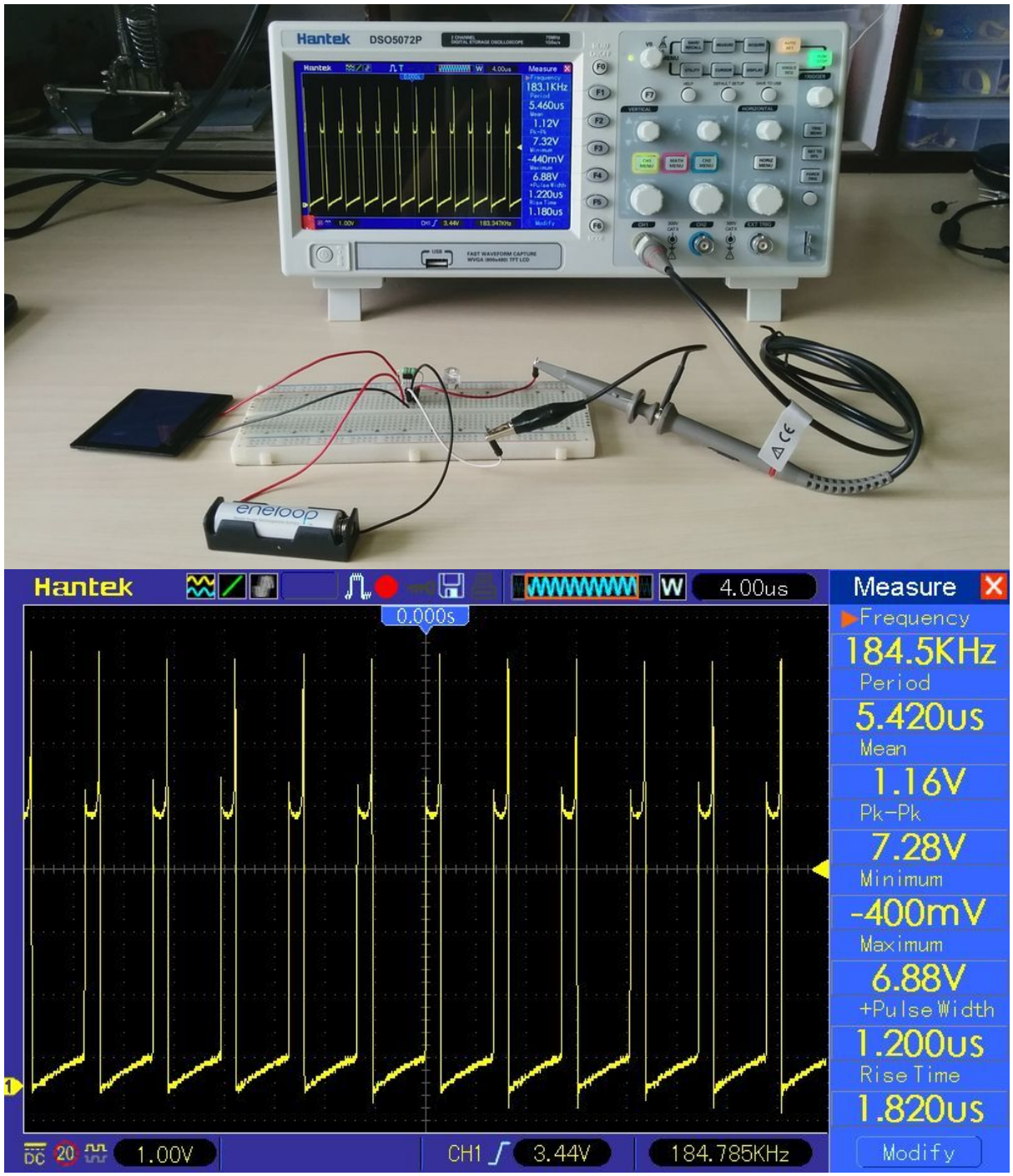
Voltage	1.3V	1.3V	1.3V	1.3V	1.3V	1.3V	1.3V	1.3V	1.3V
L	330uH	270uH	220uH	150uH	100uH	82uH	56uH	47uH	33uH
	11mA	14.5mA	15.5mA	25mA	34.5mA	38mA	50mA	75mA	110mA

The heart of this Solar Lamp is a very small 4 legged IC QX5252F. It works similar to the "Joule Thief " circuit. But the advantage of using this chip is that it does not require a bulky and heavy toroid. It does the same job using only a simple inductor, single AA / AAA battery, and a LED.
It requires only an external inductor for making the Circuit. The LED current can be changed by using a different value inductor. The chart is shown in the above picture. I have used a 33uH inductor.

Connection

- Pin-1 -> Solar panel positive terminal
- Pin-2 -> Battery positive terminal and one leg of Inductor
- Pin-3 -> All ground (Solar panel, Battery, and LED negative terminal)
- Pin-4 -> Another leg of Inductor

Step-4: Breadboard Testing



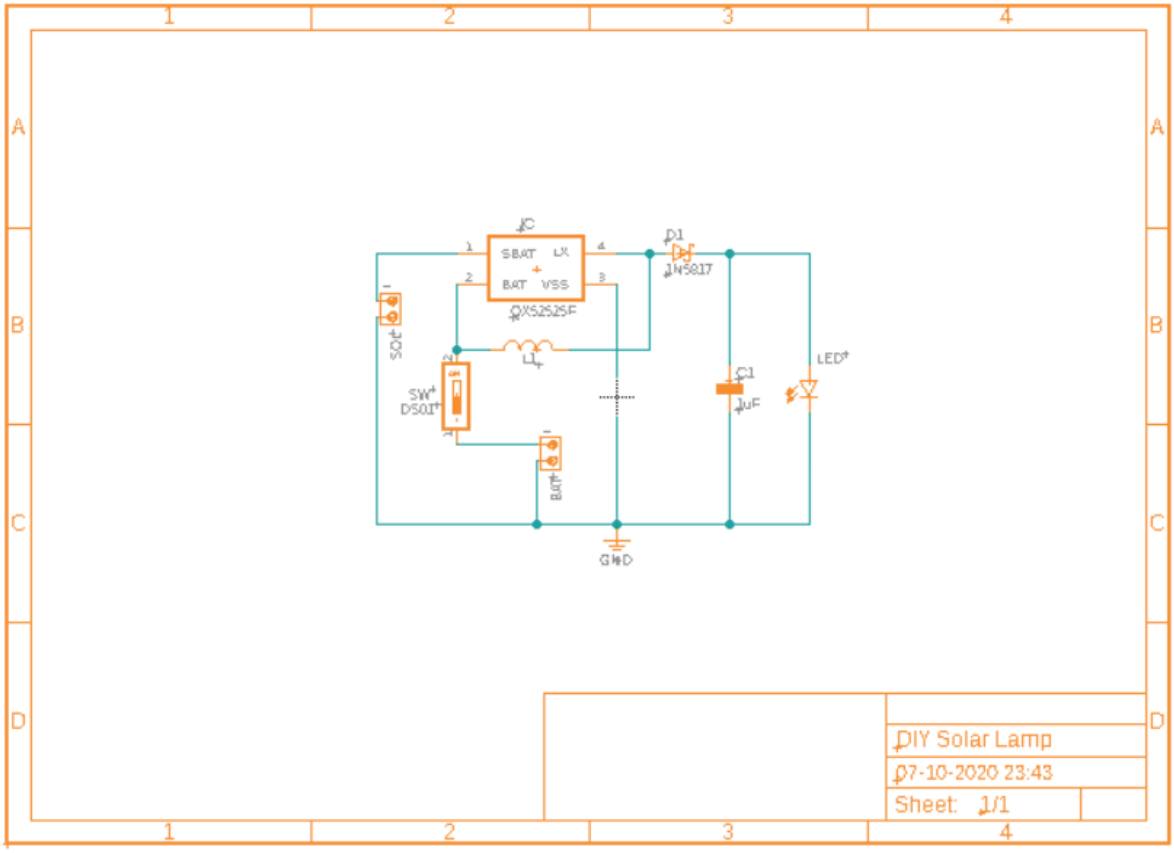
Before finalizing the circuit, It is always a good idea to prototype the circuit on a breadboard. This lets you check to make sure that all of your components are working perfectly.

Make the circuit on your bread bard as per the schematic. The LED should not glow if the circuit is correct. To simulate the dark condition, cover the solar panel with your palm. Now the LED should glow.

To check the performance of the circuit, remove the LED and hook up the oscilloscope probes. You will observe that the output is not a steady DC voltage rather it fluctuates rapidly. In my case, the frequency is around 184.5 kHz. The peak to peak voltage is nearly 7.28 V and the average value is around 1.0 to 1.20V.

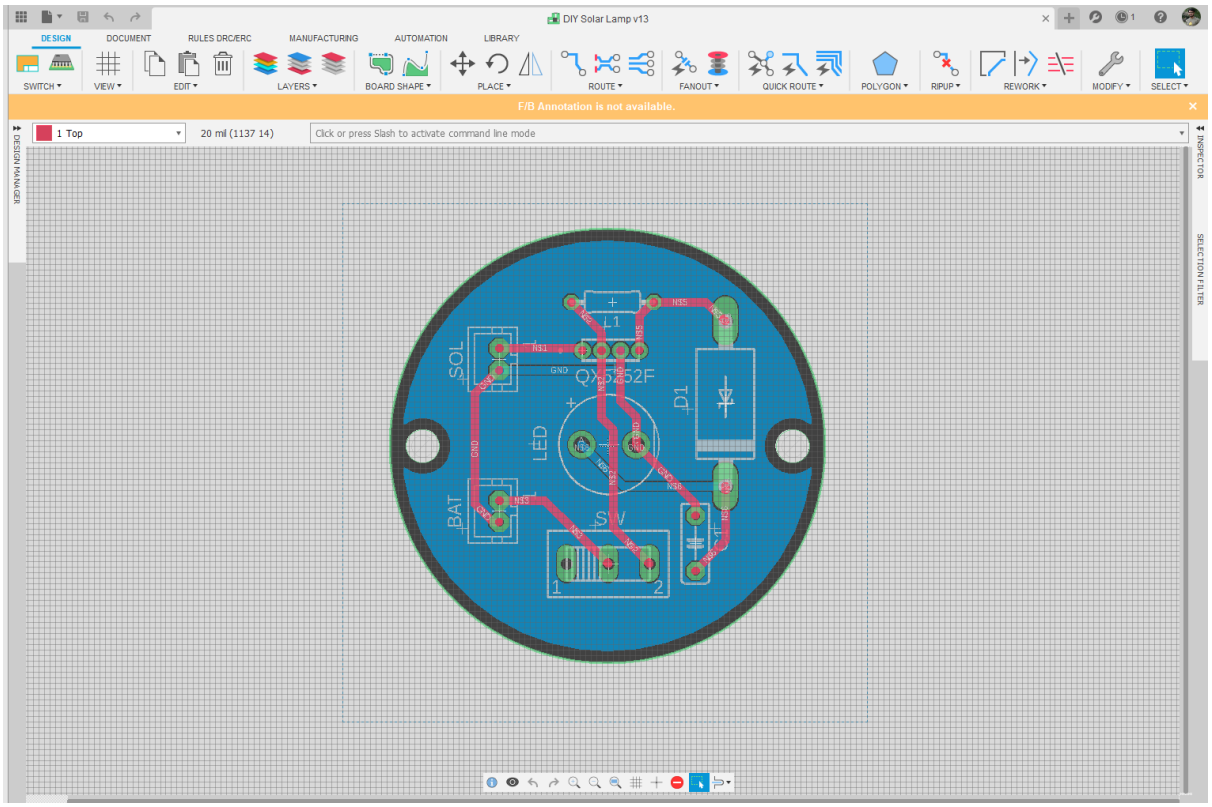
Note: *If you try to measure the voltage by a normal multimeter, it will show near to your battery voltage. Because your meters only measure the average value of a fluctuating voltage.*

Step-5: PCB Design

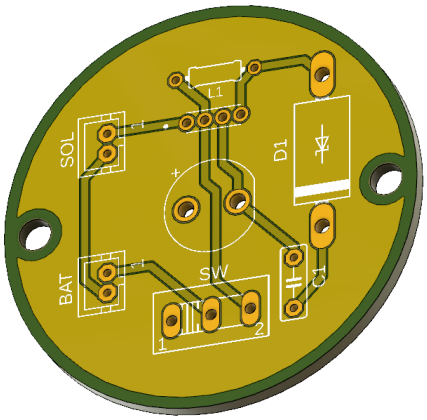


I have drawn the schematic by using Fusion 360 Electronics Design after that switched to PCB layout. All of the components you added in the schematic should be there, stacked on top of each other, ready to be placed and routed. Drag the components by grabbing on its pads. Then place it inside board outline.

I have changed the board outline from default rectangular to circular one by using the outline circle tool.



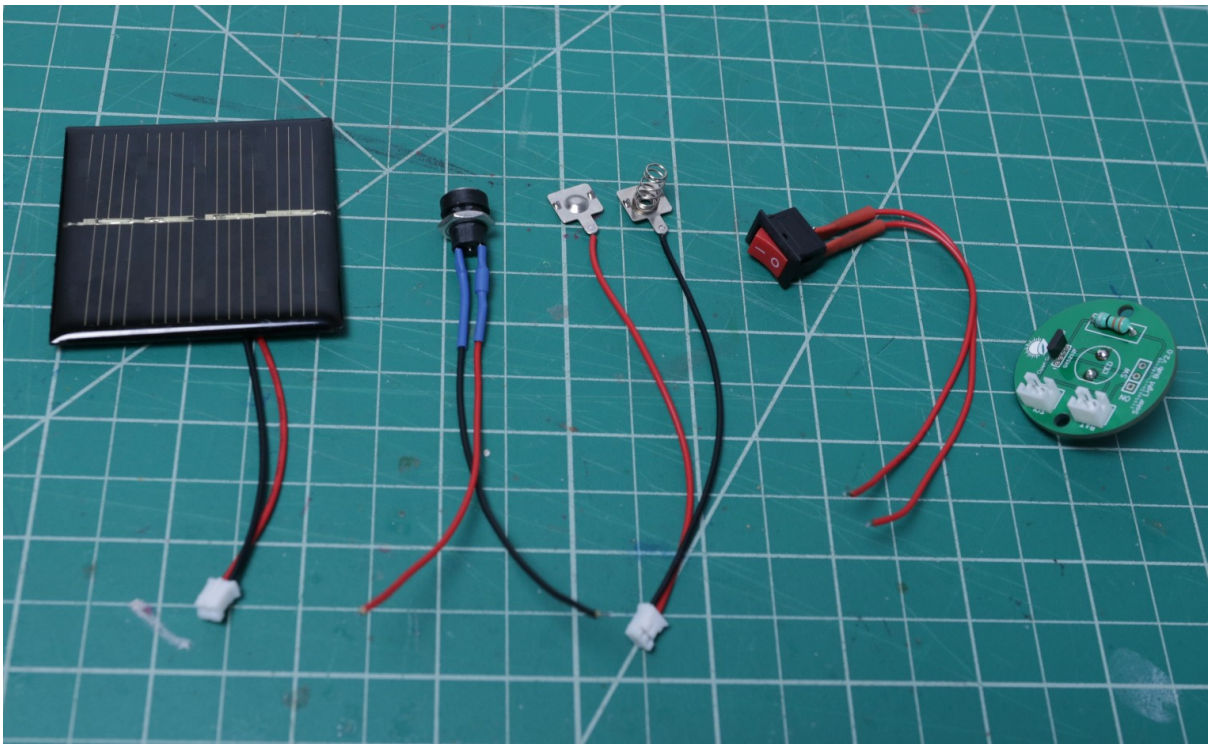
Arrange all the components in such a way that the board occupies minimum space. The smaller the board size, the cheaper will be the PCB manufacturing cost. It will be useful if this board has some mounting holes on it so that it can be mounted in an enclosure.



Now you have to route. Routing is the most fun part of this entire process. It's like solving a puzzle! Using the route tool we need to connect all the components. You can use both the top and the bottom layer for avoiding overlap between two different tracks and making the tracks shorter.
In the end, using the polygon tool, we need to create the ground area of the PCB.

Now the PCB is ready for manufacturing.

Step-6: Solder the Components



It is good practice to solder the components according to their height. Solder the lesser height components first.

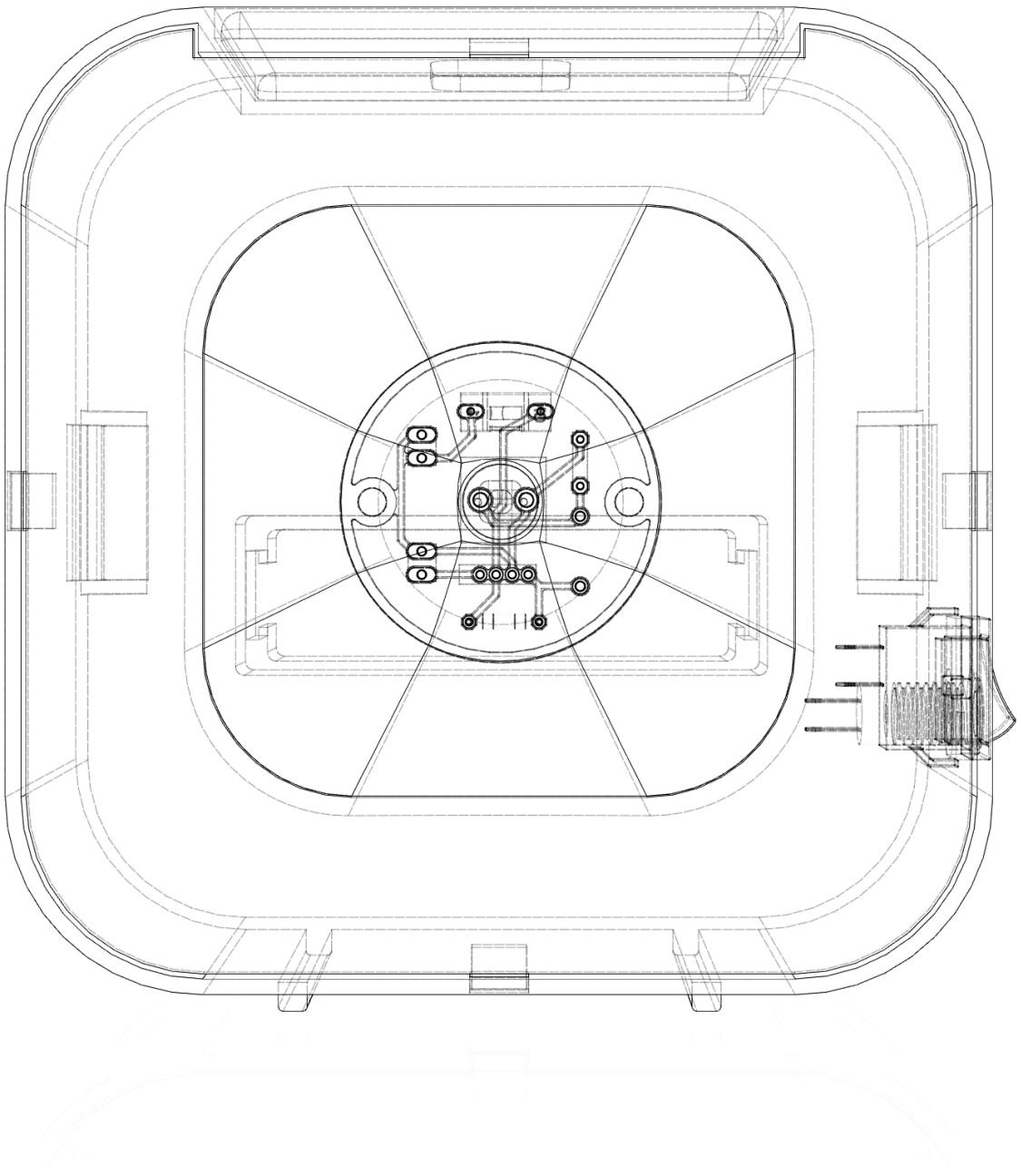
You can follow the following steps to solder the components :

- Push the component legs through their holes, and turn the PCB on its back.
- Hold the tip of the soldering iron to the junction of the pad and the leg of the component.
- Feed solder into the joint so that it flows all around the lead and covers the pad. Once it has flowed all around, move the tip away.

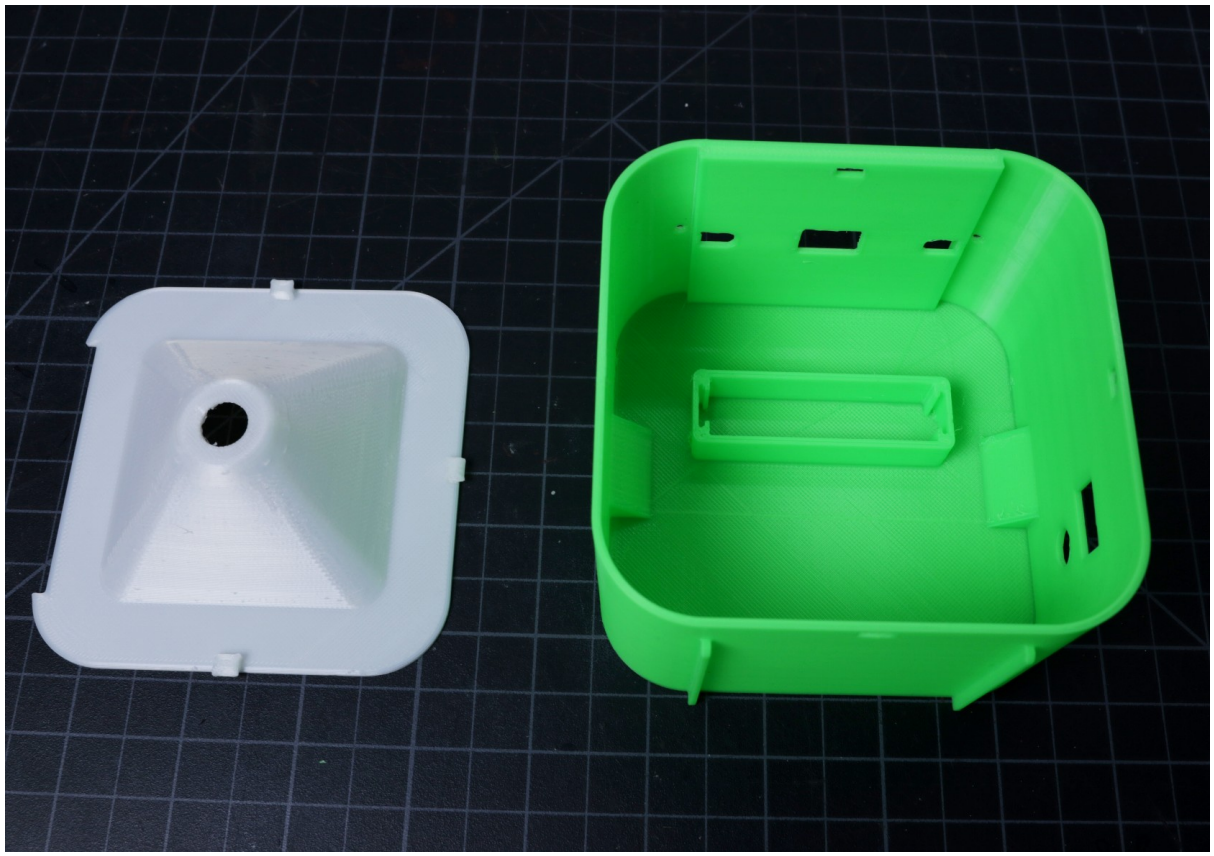
First I have soldered the inductor, then the two JST connectors, and QX5252F.
At last, I have soldered the LED on the backside of the PCB. The reason for soldering the LED on the backside is that it will be easier to mount into the Front Reflector.

Step-7: 3D Printed Enclosure Design

Follow the video tutorial to create the enclosure in Autodesk Fusion 360.



Step-8: Printing the Enclosure



The enclosure has two parts:

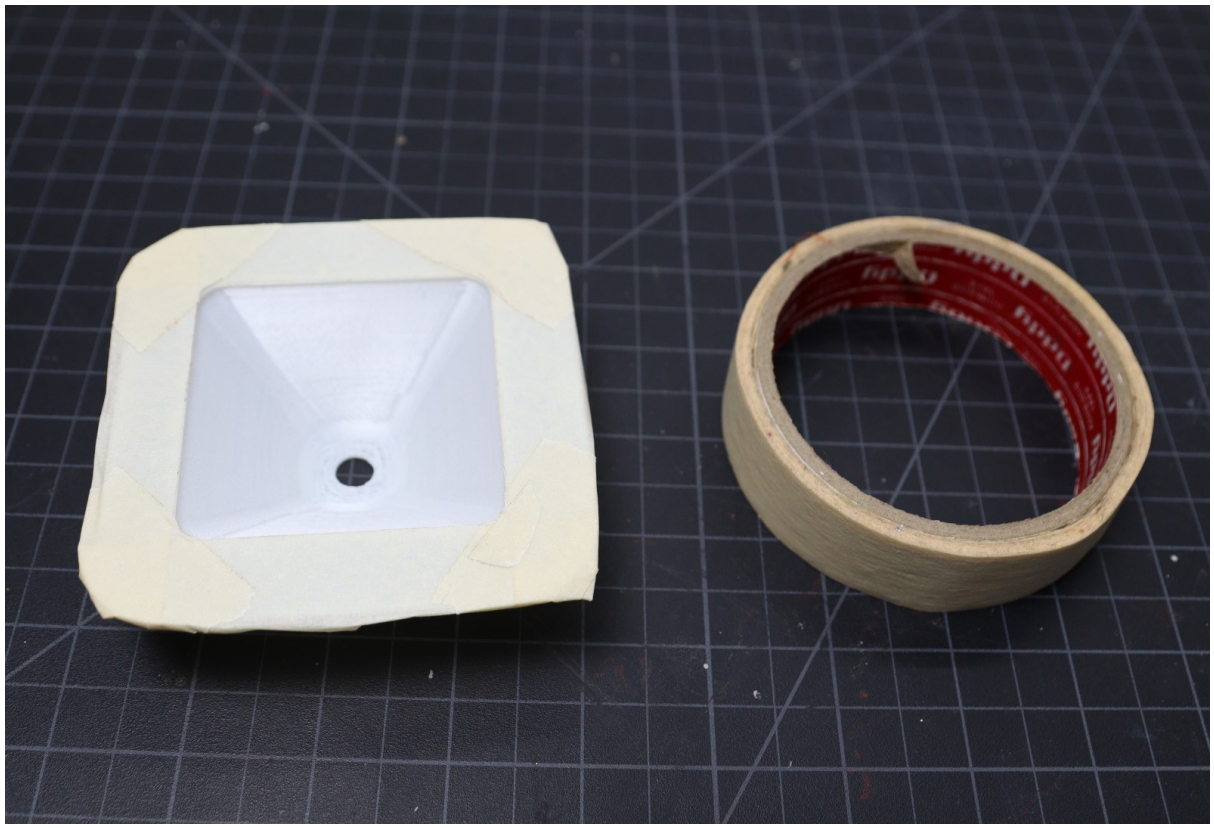
- Main Body
- Front Reflector

The Main Body is basically designed to fit all the components including the battery. The front Cover is to cover up the main body and serve as LED reflector to spread the light from the LED. I have used my Creality CR-10S printer and 1.75 mm Green and White PLA filaments to print the parts. It took me about 5 hours to print the main body and around 2 hours to print the front reflector.

My settings are:

- Print Speed: 60 mm/s
- Layer Height: 0.2mm (0.3 also works well)
- Fill Density: 25%
- Extruder Temperature: 200 deg C
- Bed Temp: 60 deg C

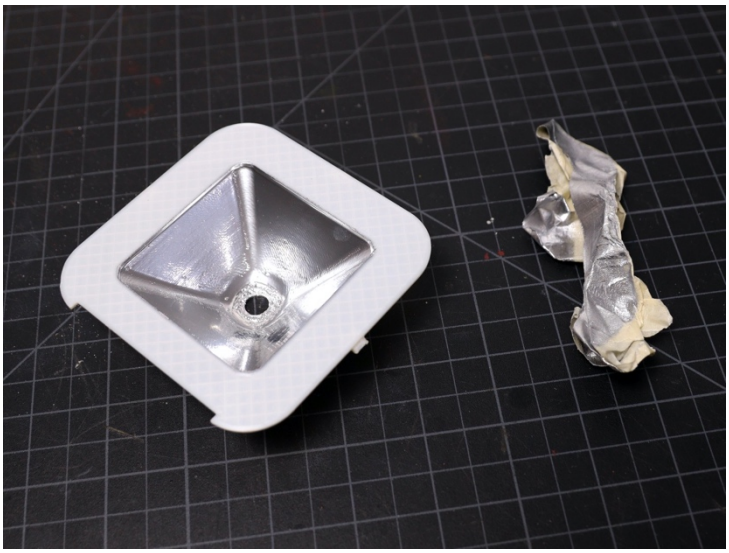
Step-9: Preparing the Reflector



The reflector can be purchased directly from the market, but to reduce the cost, it is considered to be a part of the 3D printed enclosure. Only you have to apply few coats of reflective spray-paint on the 3d printed reflector. Here I have used bright chrome spray paint, it works really nice.

Before applying the paint, cover the edges of the enclosure with a masking tape, so that paint will be only applied on the reflector part.

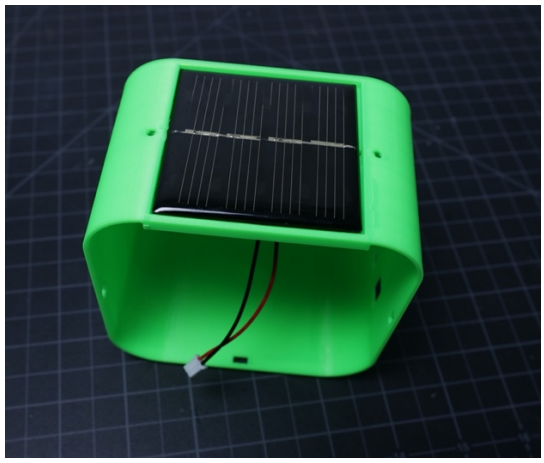
Apply the spray paint over the enclosure surface. Then leave it 10 -15 minutes to dry out. Repeat the same process for 2 to 3 times (2-3 coats). It depends on you, how much smoothness you like. After the final coat, leave it for 3-4 hours for complete drying.

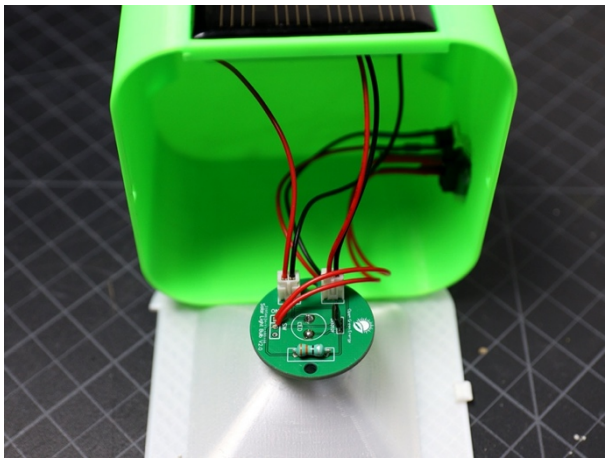


Safety: Wear nose musk during applying the spray-paint. I will recommend to do it outside and a well-ventilated space.

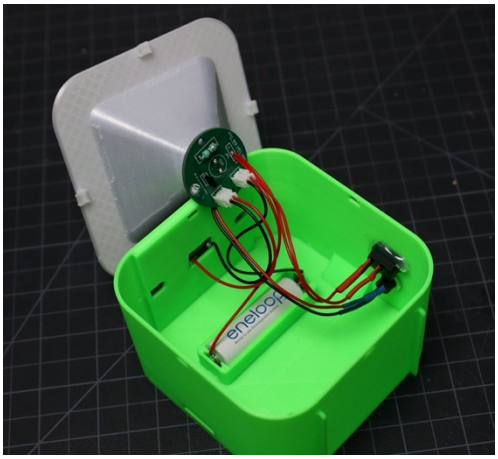
Step-10: Install the Components

Install the Solar panel on the top of the enclosure. The solar panel that I used is 58 x58 mm. Then install the DC jack and rocker switch.

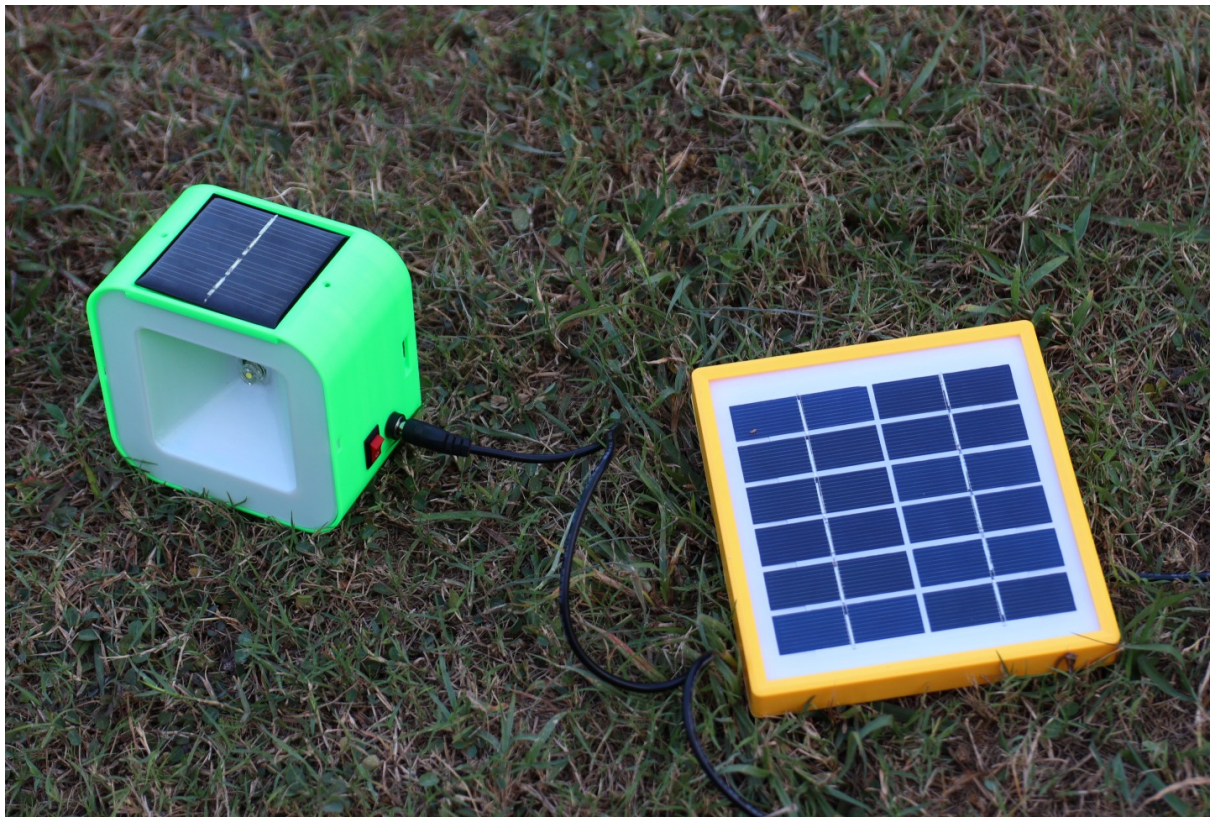




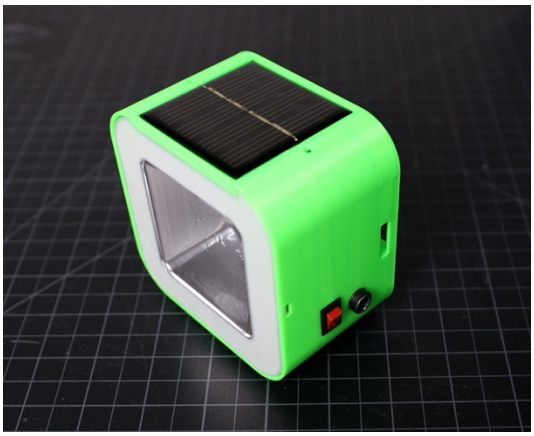
At last install the PCB on the front reflector. Use hot glue to fix all the components with the 3D printed enclosure.
The enclosure is a snap fit type, so we will not require additional mounting screws. Just align the tabs in the front reflector to the slots in the main body and then press it.



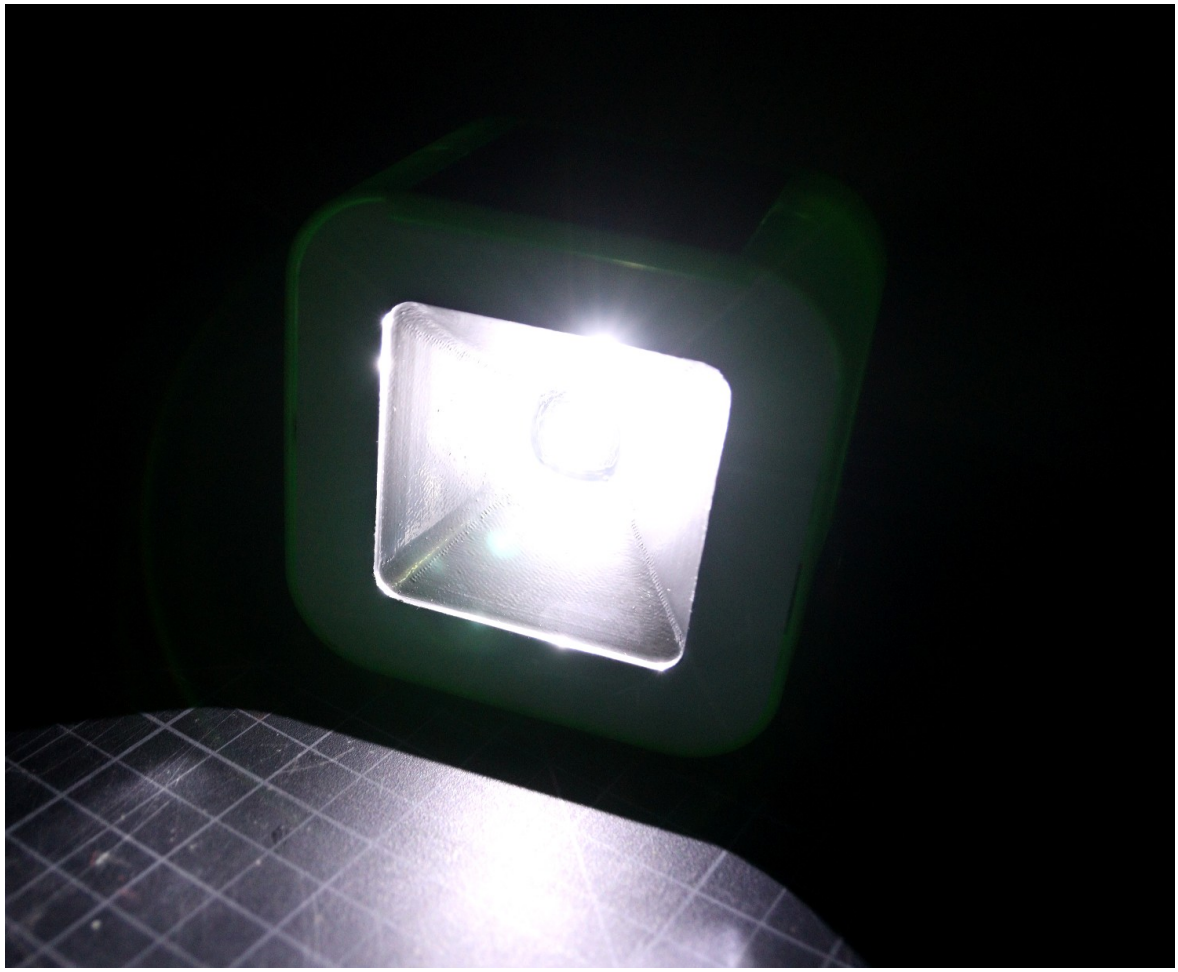
Step-11: Testing the Lamp



To test the lamp, cover the solar panel by your palm, the LED should glow. If the LED light up, then the circuit is working perfectly.



Before using the lamp, it is recommended to charge the battery on a bright sun light.



You can place the lamp outside or you can keep the lamp inside and use an external solar panel (4 to 5V) to charge the lamp.

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